

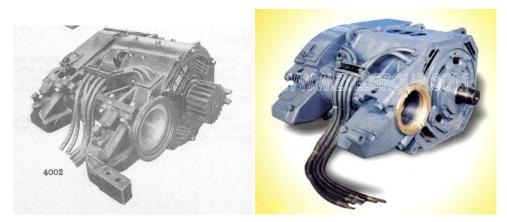
Locomotive Phases

- No locomotive manufacturer ever used the term phase for its locomotive or any of its parts
 - Changes that occurred during production of a particular model were just evolutionary steps
- The term phase was originally used by the publication, *Extra 2200 South*, started by rail historian and enthusiast Jerry Pinkepank, to identify changes in specific models
 - For example, there were 6 different phases of EMD F3s
- The use of phases to identify different characteristics of the same model was expanded by other rail historians

DC Traction Motors

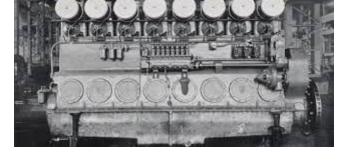
- Best to Worst
 - Westinghouse 360 to 370 Series
 - Introduced in the late 1920s
 - Westinghouse exited the locomotive traction business in 1955
 - General Electric 752 Series
 - Evolution of the 726 to 746 series
 - Introduced in the late 1940s
 - Last produced domestically for new locomotives in 2015, still produced for international customers
 - EMD D Series (D7 D100)
 - Based on the GE 716 traction motor, which EMD bought the rights for production
 - Introduced in 1938
 - Last produced domestically for new locomotives in 2011, still produced for international customers
 - MPI/MK Rail MK 1000 Series
 - Based on EMD traction motors
 - Introduced in the early 1990s, still produced upon request
- Durability Length of time to run with excessive amps
 - Based on amount of copper wiring in motor
 - Southern Pacific performed study to confirm





Manufacturers' Diesel Engines

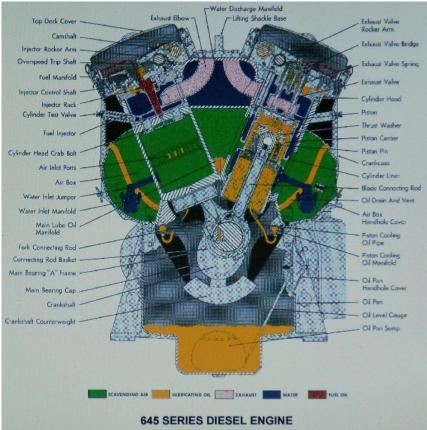
- Only 2 of the major diesel locomotive manufacturers developed and built their own diesel engines
 - EMD
 - Fairbanks-Morse
- Origins of diesel engines for other manufacturers
 - Alco purchased McIntosh & Seymour in 1929
 - Prior to 1929, Alco used Ingersoll-Rand diesel engines
 - Baldwin purchased I. P. Morris & De La Vergne in 1931



- Prior to 1931, Baldwin used Krupp and Knudsen diesel engines in locomotive development
- The last 3 locomotives built used Maybach diesel engines
- General Electric rights for the 7FDL diesel engine purchased from Cooper-Bessemer in 1956
 - Prior to 1956, GE used Buda, Busch-Sulzer, Caterpillar, Cooper-Bessemer, Cummins, Hercules, and Ingersoll-Rand, depending upon model and buyer
 - 44-ton used Caterpillar engines, and the 70-ton used the Cooper-Bessemer FWL-6T
- Lima merged with General Machinery Corp of Hamilton, Ohio in 1947
- MPI/MK Rail Primarily used EMD, but also Caterpillar, Cummins, General Electric, and Sulzer (Swiss)
- Others Krauss-Maffei (Maybach), Siemens (Cummins), Budd RDC (GM Detroit Diesel), Alstom (EMD)
- Small industrial switchers variety of domestic gasoline and diesel engines, including truck type

Locomotive Statistics

- Model number (if there is a number)
- Horsepower
- Type of trucks
- Traffic effort (if known)
- Prime mover and engine type
- Traction motors (if known)
- Total quantity built
 - Operator w/largest number of locomotives
 - Operator w/smallest number of locomotives
- Phases
- Any other relevant information



KraussMaffei (KM) Diesel Hydraulics

- Founded in 1838 by Joseph Anton Maffei in Munich as Maffei
- Merged in in 1931 with Krauss & Co., another Munich firm
- Both had been major steam locomotive manufacturers
- KM began experimentation and production of diesel locomotives in the 1930s
 - Produced diesel powered buses and developed magnetic levitation trains
 - Produced tanks and other armored vehicles beginning in the 1930s and post war for Germany and other countries, including the Leopard and Leopard 2 tanks
 - Produced manufacturing equipment for plastics and rubber beginning in 1957
- Mannesmann acquired in 1989, merged with Demag in 1999, which was acquired by Vodafone in 2000, which spun off the locomotive business to Siemens AG
 - Defense component was spun off and merged with Wegman & Co. to form Krauss-Maffei Wegman
 - Plastics and rubber manufacturing component was acquired by ChemChina in 2016



How a Diesel Hydraulic Works

• Drive components

- Engine (Maybach)
- Torque Converter Transmission (Voith)
- Cardan Shafts
- Gear Boxes



Raison D'être for KM Diesel Hydraulics

- D. J. Russell, CEO of SP, was angry that HIS railroad had been one-upped by the UP because of a joint announcement from UP and EMD to develop turbocharged locomotives
 - Mr. Russell wanted a talking point to prove SP was the new Standard Railroad of the World
- Higher train speeds and tonnage to compete with the trucking industry
 - For western railroads, this meant 8 to 12 current, conventional locomotives
- Insistence by railroads and resistance by manufacturers to raise horsepower and tractive effort
 - Railroads wanted 3,000 to 4,000 hp
 - Domestic manufacturers did not have technology to meet this requirement
 - European manufacturers, especially KM, had an offering of a 4,000 hp locomotive
 - SP report, "A Study of New Locomotive Types Available for Future Power Requirements Together with Conversion Possibilities for Existing Locomotives"
 - KM promoted hydraulic drive in lieu of traction motors



Brief Domestic History of Diesel Hydraulics

• Plymouth Locomotive Works

- Produced 3 small diesel hydraulics (8 to 10 tons), rigid frame 4-wheel switchers, between 1932 and 1934 (model DLD), all for industrial use, continued in production for many years
- Produced approximately 48 rigid frame 4-wheel or 6-wheel, 70 ton industrial switchers between 1939 and 1949
- Produced for nearly 5 decades the 65 to 120-ton, B-B CR8 industrial switcher, none or a common-carrier railroad, ceased production in 1997
 - Dozens produced with some provided to Republic of Vietnam
 - Continues to be operated by the Railways of Vietnam
 - Copied by the Chinese and is believed to still be in production
 - Recognized as the most successful diesel hydraulic locomotive design in the Western Hemisphere



Brief Domestic History of DH cont.

- The first American trucked diesel hydraulic locomotive is credited to Davenport-Beseler Corp, a 400 hp B-B industrial switcher, constructed in 1939
- Between 1947 and 1956, dozens of rigid 4-wheel, 35 to 40 ton industrial switchers were constructed by Whitcomb Locomotive Co., which were ultimately marketed under the BLH name
- In 1951, EMD produced an experimental 340 hp diesel hydraulic switcher
 - Never left La Grange, used as a shop switcher, and scrapped many years later
- General Motors Diesel of Canada produced 6 GMDH-1 locomotives between 1956 to 1960 of different horsepowers and weights, 4 B-B, 2 rigid frame 6-wheel, none to common-carrier railroads, used Allison torque converters
- Canadian Locomotive Co. built 14 44-ton, 496 hp switchers for Canadian Pacific in 1957 to 1960, first freight locomotives for a common-carrier railroad



Brief Domestic History of DH cont.

- Budd Rail Diesel Car
 - Produced from 1949 to 1962, with 398 delivered to 25 US railroads, 3 Canadian railroads, and 5 overseas customers
 - Delivered in 5 variants
 - Used 2 275 hp GM Detroit Diesel engines with 2 Allison torque converters
 - Utilized a 1A-A1 truck arrangement
 - Capable of 85 mph, including a trailer
 - Capable of multiple unit operation
 - Longest continuous route was the Oakland to Salt Lake City run of 924 miles on the Western Pacific



Brief Domestic History of DH

- Baldwin-Lima-Hamilton (BLH)
 - BLH tried to remake itself in the mid 1950's as the premier diesel hydraulic locomotive manufacturer to common-carrier railroads
 - In 1955, one diesel hydraulic switcher was constructed for the US Army using a caterpillar V-12 500 hp engine and a 3-speed forward/1-speed reverse Mekydro torque converter manufactured by Maybach
 - Was frequently borrowed back from the Army to be used as demonstrator, but never resulted in any orders
 - In 1956, BLH constructed 3 RP210H passenger locomotives to be used with the Pullman-Standard Train-X coaches
 - 2 were ordered by the New Haven, and 1 was ordered by the New York Central
 - The locomotives were powered by a single 1000 hp Maybach V-12 engine and a Mekydro torque converter (engine, torque converter and truck swiveled as a unit)
 - The New Haven units were capable of third rail operation into Grand Central Station
 - Utilized a B-2 wheel arrangement



Krauss-Maffei ML4000

- Built in Munich, Germany
 - 1961 1969
- 2 phases
 - Phase 1 was a cab unit
 - Phase 2 was a hood unit
- 2 different style of trucks
 - Cab unit had European style of three axle truck
 - Hood unit had an American style of three axle truck
- Rated at 4,000 hp, actual hp at rail was 3,540 hp
 - KM used different method to calculate hp
- Tractive effort
 - Starting tractive effort was 106,000 lbs (F7A 64,000 lbs at 62:15 gear ratio)
 - Continuous Tractive effort was 78,000 lbs (N&W Class A 114,000 lbs)
- Engines 2 light-weight, high-rpm Maybach MD870 V-16, 4 stroke
 - EMD 567 engine is approximately 50% bigger, and is considered a medium speed
- Torque Converter/Transmission Voith L830rU hydraulic
- American made subassemblies couplers, draft gear, air brakes, compressors, headlight, wheels, brake shoes, roller bearings, sanders, and safety appliances
- Fasteners engines and torque converters used metric, all other parts used American standard thread English system
- Control system was pneumatic in order to minimize the electrical load of accessories



KM ML 4000 cont.

- Number Produced
 - SP wanted 3; KM needed 5 for "cost-effective" production
 - SP arm-wrestled Rio Grande into buying three
 - Order for 6 cab units placed in 1959 and delivered in October 1961
 - Lost to history as to why cab units were ordered
 - In January 1963, SP ordered 15 more ML 4000s hood style with 8 improvements over cab units, delivered in February 1964
 - Improvements included American style trucks and electropneumatic controls
 - RFPs had been sent to North American and European manufacturers for 21 locomotives
 - Only Alco responded from US, which received an order for 3 hood units
 - Estrada de Ferro Vitória a Minas (Brazil) accepted 4 hood units in 1966 and 12 in 1969 to be used on meter gauge track (retired in 1980)



Results of the Diesel Hydraulic Experiment

- NYC and D&H expressed interest and 2 Rio Grande units sent east in 1962 as demonstrators, but no orders occurred
- All KM units retired by 1968
 - Rio Grande cab units transferred to SP in 1964, and most cab units retired in 1966
- ML 4000 proved it could pull like no other diesel in North America
 - In the mid-1960's, the 21 KMs, along with 3 Alco DHs, handled most of freight tonnage in the San Joaquin Valley of CA
 - ML 4000s were considered to be reliable and tough
- Disadvantages
 - Unsatisfactory in mountain service and in the desert
 - Cooling system was inadequate for American service
 - Cab units would not run with other diesels because of pneumatic controls
 - Maybach engine and Voith torque converter were labor intensive
 - Maintenance was specialized so could not be used system-wide
 - New Alco, EMD, and GE diesel electric models coming online that negated the hp and tractive effort advantage of the KMs (Alco C630 and C636, EMD SD40/SD45, and GE U33C/U33C)
- SP spent \$10M on a dead end technology, but the ML 4000s pushed the "state of art" in the competing diesel electric technology





ML 4000 Preservation

- SP 9010 (Renumbered by SP to 9113)
 - Retired in 1968
 - Converted to camera car in 1968-1969 to record trackage for training simulation
 - Numbered SPMW1, renumbered to SPMW1166, renumbered to 8799
 - Nose rebuilt to house camera equipment
 - Both engines and rear torque converter left in place for weight, front torque converter replaced with small genset to power camera equipment
 - Retired in 1984 and donated to CA State RR Museum in 1986
 - Museum wanted to restore unit to original, no progress beyond removal of nose
 - Donated to Pacific Locomotive Association in 2008 and moved to the Niles Canyon Railway for restoration
 - Acquired KM trucks from a Plasser ballast machine in 2013, and in 2015 acquired new cardan shafts from Welte Group of Germany (trucks from ML 4000s retired in 1968)
 - In February 2017, rear Maybach engine was restarted after 48 years on first try
 - On March 1, 2017, 9010 operated under its own power, and began excursion service on July 20, 2019 between Sonol and Fremont, CA



Modeling the ML 4000

- Models have been produced in O, HO, N, and Z scales
 - AHM produced a HO plastic model in the 1960s and 1970s
 - Overland produced brass N, HO and O for both cabs and hoods
 - Division Point and Union Terminal Imports produced HO brass for both cabs and hoods
 - UTI produced an exquisite hood model with DCC, sound and fully detailed and painted interior in HO 4 years ago (UTI's last)
 - American Z Line produced a brass Z scale model, other scales?





Questions

WHITEWATER VALLEY